

HDP SYSTEM A PYROS DID NOT DETONATE DURING STS-112 LAUNCH

Element/End Item: 104
Flow/Usage: **FLT28**
Facility: **OPF1**
Design Center Concurrence: **KSC**
Category:
OPR: **EPD**
TTL ORG: **SE**

**This document does not contain
hazardous operations.**

Approval Record

HDP SYSTEM A PYROS DID NOT DETONATE DURING STS-112 LAUNCH

Technical Contact: Dan Barnes Phone: 1-4291

| Category II TOP Only |
|---|
| This Approval Record is for all Operation No(s) listed below: |
| Initial Released Operations: _____ |
| Added Operations: _____ |
| Deleted Operations: _____ |
| Replaced Operations: _____ |
| Change Index Added _____ |
| Comments: _____ |
| _____ |
| _____ |
| Check Family Type: In Family[<input type="checkbox"/>] Out of Family[<input checked="" type="checkbox"/>] NMA[<input type="checkbox"/>] |

| Organization | Name (Printed) | Name (Signature) | Date |
|--------------|----------------|------------------|------|
| USA/EPD SE | | | |
| USA EPD SS | | | |
| NASA ELEC SE | | | |
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| USA/Chief Eng | | | |
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1.0 INFORMATION

1.3 Operations List

| Operation | | Shop/ Cntl Rm Console | OPR | Haz (Y/N) | Duration (Hrs) |
|-----------|-------------|-----------------------------|-----|--------------|-------------------|
| No. | Title | | | | |
| 20 | U/A CLOSURE | N/A/ C10 | EPD | N | |
| 1.5 | | | | | |

2.0 SAFETY INFORMATION

2.4 Reference Safety Documentation

| Number | Rev | Title |
|------------|-----|-----------------------------------|
| KHB 1710.2 | LI | KSC Safety Practices Handbook |
| GSOP 5400 | LI | Ground Safety Operating Procedure |

3.0 STAGING REQUIREMENTS

4.0 PLANNING REQUIREMENTS

OIR Required Yes [], No [X]

Predecessors:

Successors:

Configuration Required:

5.0 CONFIGURATION ACCOUNTING AND VERIFICATION

OPERATION 20 U/A CLOSURE

Shop: N/A

Cntrl Rm Console: C10

OPR: EPD

Zone: 300

Hazard (Y/N): N

Duration (Hrs): 1.5

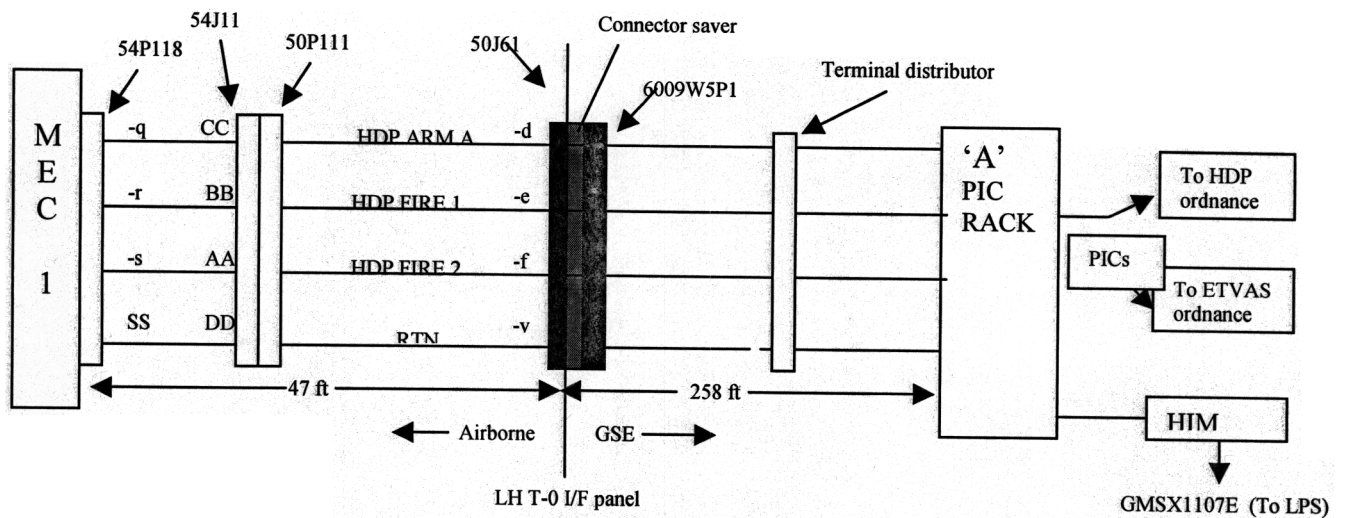
U/A RATIONALE

Ref. Item #

ACTION REQUESTED- Recommend approval and acceptance of disposition for UNEXPLAINED ANOMALY per the following rational:

Description of Problem-

Just after T-0 during the launch of STS-112 on 10/07/02 at approximately 1545 ET, the GLS software in Firing Room 3 annunciated a 'cutoff' condition and did not automatically issue the normal post launch safing even though the vehicle had successfully left the mobile launch platform. Real time data review revealed that the erroneous GLS indication and subsequent safing hang-up was triggered by the failure of a MLP 3 GSE indication (GMSX1107E: SYS A HDP T-0 Bus On Indication) to transition from OFF to ON at T-0. Starting at T-2 seconds, GLS continuously monitors both the SYS A and SYS B HDP T-0 Bus On indications and requires that both (2 of 2) be ON as confirmation that liftoff has occurred and before it will issue post launch safing. More detailed post-launch data review then showed that the MLP 3 Hold Down Post (HDP), ET Vent Arm System (ETVAS) and ETVAS Lanyard 'A' circuit pyrotechnic devices did not receive detonation energy as expected from the MLP 3 system A PICs (Pyrotechnic Initiation Controller). The F1 and F2 switch indicators did not come on, indicating that the F1 and F2 commands were not processed by the PICs. Since the PIC rack did not see all three requisite commands in the proper sequence, it did not issue the detonation energy to the A circuit HDP or ETVAS ordnance. Of the three signals, only the ARM signal could be positively verified as reaching the PICs.



All three of these commands along with their return are routed from MEC1 (Master Events Controller, located in the aft of the Orbiter in avionics bay 4) to the MLP PIC rack (located in MLP compartment 7A) via separate, discrete sockets/wires in LH T-0 connector 50J61. The redundant 'B' circuits for the HDP and ETVAS pyrotechnics, which are issued at the same time as the 'A' commands, were unaffected at T-0 and did detonate the 'B' side pyros properly. Because of the redundant design of the HDP frangible nuts and the ETVAS bolt, there was still a 'clean' HDP and ETVAS mechanical release at T-0, and thus, a successful launch.

Troubleshooting Description –

Due to the serious (and possibly catastrophic) SSV structural consequences that could happen should the 'B' side HDP, ETVAS and ETVAS Lanyard pyrotechnic system fail at the same time as the 'A' system, a formal Incident Review team was assembled to examine this launch anomaly. The following is a summary of the T/S actions taken as a result of team direction, roughly listed in the chronological order:

While the STS-112 mission was still in progress and the Orbiter (OV-104) unavailable for T/S, the MLP 3 GSE portion of the HDP/ETVAS sys A detonation circuitry was examined visually, electrically and functionally tested. Visual inspection included the GSE connector (6009W5P1) that mates to the T-0 connector 50J61 on the Orbiter, all the GSE cabling/wiring between the LH T-0 connector and the PIC CPA, and the internal PIC CPA itself. No failures were found. Electrical tests of the wiring/cabling between the T-0 cable and PIC CPA were performed in place including; static continuity, flex continuity and Insulation Resistance (IR), all with no

anomalies. ALL GSE cables were removed and sent to the Malfunction Lab. Failure analysis of connectors, cables & wires included: high power visual inspection; 360 degree X-ray, Contamination analysis, socket grip force measurement, pin retention tests, pin dimensional analysis, pin/socket contact analysis, T-0 spring constant/force measurement, and T-0 spring free length measurement were performed as well. The spring force for the J61 connector was found to be at 45.6 pounds. The T-0 connector retention springs have a SPEC requirement of 63 +/- 5 lbs. . The CPA was removed opened, inspected and the command line circuits were continuity and IR checked. The CPA was reinstalled and functional testing was performed using pulsed signals for the F1 command line to simulate an intermittent T-0 connection. Frequencies were consistent with those encountered with launch vibration data.

- Immediately following the landing of STS-112 at KSC, the 50J61 connector and connector saver at the Orbiter LH T-0 panel were examined and photographed, and samples taken around the periphery of the suspect contacts. Connector saver bayonet locking pins were inspected and found to be locked in place. Resistance checks of the HDP Sys A Fire 1 and Fire 2 lines back into the MEC 1 driver circuitry were taken. This was done prior to Orbiter tow to OPF. No anomalies were observed.
- Following tow-in to OPF 1, 50J61 was not connected to the normal OPF support GSE. Instead, the HDP sys A ARM, FIRE 1 and FIRE 2 circuits out of the 50J61 connector were connected to special test GSE and monitored while MEC 1 was activated and the applicable commands for these functions sent. The commands were sent several different times and the results recorded. No failures were noted during this testing; i.e., the MEC sent the commands properly and the signals were present at the appropriate T-0 connector pins.

Again the MECs were powered up and measurement made using the Nicolet recorder. The HDP commands were monitored at the T-0 while the harness between 50J61 and 54P118 were flexed. The Arm, F1, F2/F3 commands were issued while a pull test was performed on the following connectors: 50J61, 50P111, 54J11 and 54P118.

- OEL engineering replaced the firing lines from the MEC to the 50J61 connector and the lines were sent to the Malfunction lab. Additionally, an AMEC was installed in slot 1 in Av Bay 4. This MEC was functionally tested in the KATS lab.

Sypris Test & Measurement Company was independently contracted to perform a Failure Analysis/Teardown/Investigation on half a cable (79K12584-19) and connector saver (ME414-0630-1001). All of the Pins, with the exception of one (located at the center of the Connector), were found to contain some foreign dark-green / dark-brown / greenish-blue residue / material on the tip and on the cylindrical length of each of the Pins. The content and location of this residue / material was irregular and asymmetric. This foreign material or residue was identified to be highly rich in Chlorine (Cl) as a result of formation of HCL which is produced as a result of the volatile environment (created by the SRBs). The material on the pins was found to be non-conductive.

- All of the Pins of the Cable and Pin and Sockets of the Connector Saver were tested for Continuity. All passed the continuity test. The Resistance measured was less than 0.3 ohms. This includes the Resistance path of the test setup. No anomalies, residues, or intermetallics were observed with the Pins, in or on the Sockets of the Connector Saver. No other defects or Cable damage were observed during the External Visual of the Cables.
- In summary, all of the suspect components and circuits were subjected to rigorous inspections, electrical tests, functional tests and failure analysis. No single cause for the anomaly could be identified

Prior Occurrences-

There have been no prior occurrences of the failure of an entire HDP pyro circuit to function at T-0. However, there have been past problems with signals that communicate with supporting GSE through T-0 connectors that could be of significance to this IPR.

- IPR 112V-0002 (STS-112/OV-104): This IPR documented a series of problems with LPS to vehicle communication on LDB1 that occurred during the STS-112 integrated flow. Following a final dropout at the PAD after a launch scrub, the 6009W21P1 GSE connector/cable assembly was replaced along with the connector saver at 50J71. The IPR was closed as a UA with corrosion on T-0 connector 50J71 as the Most Probable Cause.
- IPR 110V-0076 (STS-110/OV-104): LDB1 I/O errors and an autoswitch occurred during S0009 on this flow (3/19/02). The problem (a distorted LDB 1 waveform from the vehicle) was observed to be present at the 900686 TD on MLP 3. The problem disappeared after T-0 umbilical

connector J71 was demated, cleaned, and remated. Thus, the fault was attributed to a 50J71 problem. IPR (110V-0122/112V-0002) is most likely a recurrence of IPR 110V-0076.

- IPR 118V-0002 (STS105/OV-103): LDB1 I/O errors and an autoswitch to LDB 2 occurred at T-4 seconds during the STS105 launch countdown on 8/14/01. STS105 used MLP 3, and thus, the same T-0 umbilical as this IPR. Post flight, this problem was troubleshot and eventually attributed to moisture accumulation found in the 9079 TD J3 connector due to A/C condensate dripping into the TD. However, it cannot be positively confirmed that moisture was present in the connector, or was responsible for the fault, at the time of STS105 launch. A fix was implemented to prevent further AC condensate intrusion into the TD. During T/S of the STS-110 LDB 1 problems, the same MLP 3 TD connectors were examined again and found to be free of any sign of moisture.
 - IPR 105V-0038: A loss of PCM 1 data occurred during the STS-105 flow (7/5/01). Signal returned spontaneously during T/S. Closed as UA.
- IPR 111V-0050: A loss of EIU 3 60KB data during the STS-111 flow (4/30/02). Signal returned after T-0 connector 50J64 demated, cleaned, remated.
- IPR 111V-0078: A second loss of EIU 3 60KB data during STS-111 scrub activities occurred on 5/30/02. No T/S was performed because of need to maintain launch configuration. Transferred to STS-113 flow. Signal became erratic again at engine start. Signal was good at first power up in OPF after mission. Pending closure as UA with 50J64 connector corrosion as MPC.
- IPR 111V-0004: SRB LH Bus A H/W Voltage measurement went to lower limits several seconds prior to T-0. Inspection of 50J61 T-0 connector immediately following landing revealed that the connector saver was not tight.

Redundancy Considerations -

There are two separate, redundant paths (A and B) to detonate the HDP and ETVAS and ETVAS Lanyard T-0 pyrotechnics. As has been demonstrated, only one functioning path is required to launch successfully.

Launch Countdown Considerations -

An exact recurrence of this problem would still result in a successful launch but would cause GLS to annunciate the same erroneous 'cutoff' indication seen last time. Post launch safing would again not be automatically issued. However, since this incident all

involved systems (Launch Accessories, EPDC, ECL, Water, MPS, LOX, and LH2) have added new sequences to S0007 that would allow them to issue the necessary post-launch safing to their respective systems if necessary.

Flight Effects -

There is no effect on flight if this problem were to recur.

Problem Detectability -

The integrity (Resistance Test) of the HDP A circuitry between the MEC and the PIC rack is last checked in OMI S0007VL2 at the T-3 hr 45 minute time frame. There is no other viable way to test the circuit once live HDP/ETVAS ordnance is connected for launch.

Possible Causes -

- An intermittent in the MEC 1 HDP release A circuitry internal to the MEC.
- An intermittent/short in the flight wiring/pins/sockets between MEC 1 connector 54P118 and intermediate connector 54J11.
- An intermittent/short in the flight wiring/pins/sockets between intermediate connector 50P111 and the T-0 receptacle 50J61.
- An intermittent or high resistance path between pin -e of 50J61 and the corresponding pin of the connector saver.

An intermittent continuity problem internal to the connector saver between the inboard pins and the outboard sockets of the connector saver.

- An intermittent or high resistance path between outboard socket -e of the connector saver at 50J61 and the corresponding pin on GSE connector 6009W5P1.

An intermittent/short in the GSE wiring between vehicle T-0 connector 6009W5P1 and the MLP 3 A PIC rack in comp 7A

- An intermittent electrical problem in the 'A' PIC CPA internal electronics/wiring.

Most Probable Cause -

The most probable cause of this anomaly is an intermittent open or high resistance connection in the HDP SYS A FIRE 1 copper path at the 50J61

connector saver-to-GSE connector interface. Although a single failure cause could not be identified, it is believed that a variety of conditions attributed to this as being the most probable cause, including:

- Recent history of several problems with similar circuits that go through T-0 cables
- Visual corrosion/contamination on T-0 connector pins
- Significantly lower than normal or required T-0 spring tension
- Shorter than allowable T-0 spring free length
- Blind mate, not verified and difficult mate process of the T-0 cables

Rationale for Acceptance for Flight -

- A recurrence of this problem alone would have no effect on flight safety or mission success.
- Process enhancements have been incorporated including: connector saver bayonet verification, T-0 connector proper mate verification with boroscope, eight foot T-0 cable replacement each flow, improved connector inspection criteria.
- The 'most probable cause hardware' (the T-0 umbilical harness/connector assembly) has been replaced, along with other critical components in the HDP firing circuit: the MEC, associated vehicle wiring between the MEC and the T-0 interface connector, the T-0 connector receptacle 50J61, the connector saver and associated GSE wiring up to the PIC rack.

Corrective Action -

The acceptability inspection criteria for the T-0 GSE cables has been changed so that corrosion that would have been acceptable in the past will no longer be acceptable and will now result in PR conditions to either clean or replace the entire T-0 assembly. These R&R criteria will be applied for the foreseeable future to all MLPs and vehicles when excessive corrosion is noted on the T-0 GSE connectors and/or connector savers. New procedures are in place to verify via videoscope the connection of T-0 cables by inspecting the bayonet pins.

Any future or additional corrective action as a result of this problem will be driven by the results of additional testing taking place in the NASA malfunction lab on the removed components. Efforts are in work to find a better method of cleaning what appears to be SRB residue off the connectors post launch.

UA Closure Category –

Since some of the possible causes cited in this UA rationale involve flight hardware components, this IPR will be upgraded to a Vehicle General PR then transferred to the

Closed UA TAIR category.

20-1 Upgrade this IPR to an OV-104 Vehicle General PR:
EICN# _____
Part name: Orbiter
Part number: V070-00001-004
OCN/SN: E004
NHA: N/A
Vendor: BNA

20-2 Transfer this PR to the OV-104 UA Closed TAIR category

WC:

20-3 Close this PR.

Qv:

*** End of Operation 20 ***